**Machine-learning correction of misalignment effects  
in density profiles from Thomson scattering**

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A number of effects can negatively impact the quality of experimental density profiles measured with laser Thomson scattering. Examples are laser misalignment, coatings on windows or detector drifts. At Wendelstein 7-X (W7-X), it was observed that vibrations and temperature changes along the beam-path lead to laser misalignment, which was the dominant error source for the electron density profiles during the first experimental campaigns. Countermeasures that are being implemented include mechanical improvements and a new calibration method, in which the laser position is monitored, both for the calibration measurements and for the actual experiments. This, however, requires a scan of laser positions during calibration, which has not been performed in the first experimental campaigns of W7-X. In order to correct existing data, the impact of laser misalignment had to be deduced from the density profiles themselves. The machine-learning based solution for this task is described in this contribution.

The first step to correct the impact of laser misalignment is to determine the laser position for the existing data, even though it has not been measured. It is not required to find the laser position in actual lab coordinates, but rather it is sufficient to distinguish different laser positions and to be able to tell which of those positions are close to each other. This is facilitated by the fact that that the laser misalignment does not impact every spatial point of the density profile (scattering volume) in the same way and, hence, leaves a characteristic fingerprint in the point-to-point variation between neighboring points in the profile. A special type of neural network, called an autoencoder, is used to classify these fingerprints and to represent them as an abstract laser position. It was shown experimentally that this abstract laser position is correlated with the actual laser position in lab coordinates. This also means that positions close to each other in one coordinate system can be assumed to also be close in the other. Consequently, the density profiles themselves contain enough information about the laser position to group profiles of similar laser positions together. In the second step, transformations between different laser positions are determined. With these transformations, profiles that have been measured at one abstract laser position can be mapped to a different one to see how the profile would look like, had it been measured at that other laser position. Finally, the abstract laser position that corresponds to the laser position during the absolute calibration has to be identified. Since in magnetically confined toroidal plasmas, density and temperature profiles are symmetric in magnetic coordinates, profiles measured close to the calibration position are more symmetric than profiles that have been measured far away from it. The reference position can be identified by ranking profiles by their symmetry. The transformation from a profile’s position to this reference position is the best estimate for the appropriate correction. Error bars can be estimated by transforming to neighboring positions. In this contribution, we apply this procedure to both synthetic data (for illustrational purpose) and experimental data.